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THE HEREDITY OF EPILEPSY ANALYZED BY THE MENDELIAN METHOD.

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(Read April 19, 1912.)

Until recently it has been considered sufficient to determine the known number of epileptic ancestors or other relatives of a case of epilepsy, and then take this proportion as the index of heredity, with the natural result that the index increased as the study of the family was extended, resulting in a difference of from 20 to 75 per cent., as determined by different workers.

In our study of the inheritance of epilepsy at Skillman, we are endeavoring to analyze our data by the Mendelian method, which assumes that the inheritance of any character is not from the parents, grandparents, etc., but from the germ plasm out of which every fraternity and its parents and other relatives have arisen.

The relation of soma (body) and germ plasm is as follows:

1. If the body possesses a trait of the recessive to normality sort, it lacks the unit character upon which normal development depends, and it is *prima facie* evidence that the representative of that character is absent from its germ plasm, consequently such a person cannot transmit the character in question. The condition in the case when the determiner is absent may be called nulliplex.

2. If the body possesses a trait of the dominant to normality sort, it is evidence that the germ plasm has the corresponding determiner. But either one of two conditions is possible. (*a*) The determiner was derived from both parents, so that it is double in the germ plasm, and all the germ cells have the determiner; or else, (*b*) it came from one parent only, in which case it is single in the germ plasm, or simplex, and half of the germ cells have the determiner and half lack the determiner.

A moment's consideration will show that three kinds of somatic

and six kinds of germ plasm matings, disregarding sex, are possible. These latter matings, together with the sort of offspring they may be expected to yield, are as follows:

- I. Nulliplex \times Nulliplex = 100 per cent. Nulliplex.
- II. Nulliplex \times Simplex = 50 per cent. Nulliplex; 50 per cent. Simplex.
- III. Simplex \times Simplex = 25 per cent. Nulliplex; 50 per cent. Simplex; 25 per cent. Duplex.
- IV. Nulliplex \times Duplex = 100 per cent. Simplex.
- V. Simplex \times Duplex = 50 per cent. Duplex; 50 per cent. Simplex.
- VI. Duplex \times Duplex = 100 per cent. Duplex.

Practically, it is not always easy to distinguish the simplex from

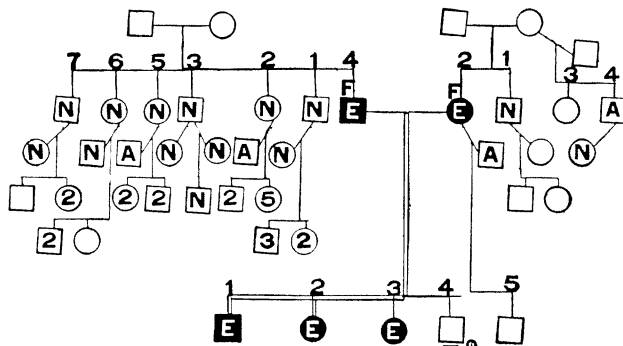


FIG. 1. In the above chart both of the parents are epileptic. There were four children from this mating, three of them were epileptic and the fourth, after the chart was made, was discovered to be feeble-minded. This case is of the type nulliplex \times nulliplex. *E*, epileptic; *F*, feeble-minded; *A*, alcoholic; *N*, normal. Case 3,667.

the duplex condition, although frequently a simplex condition is indicated by an intermediate mental status.

The new method of obtaining the material is largely responsible for any advance which has been made in the study of the inheritance of epilepsy.

The field workers visit the parents and other relatives of the patient and interview them in their homes, where they are at ease, and free from restraining influences, as would not be possible elsewhere. The family physician, clergyman, school teacher and other interested persons are also interviewed, for the purpose of securing an accurate account of the mental status, environmental conditions,

diseases, and causes of death, if dead, of as many relatives of the patient as possible.

The data thus obtained are recorded and tabulated on a heredity card, in such a manner that future additions and corrections can be easily made, without destroying or detracting from the work done to date.

The history and chart are filed with the case records. A cross index of place, name and trait help to locate the defective strain by

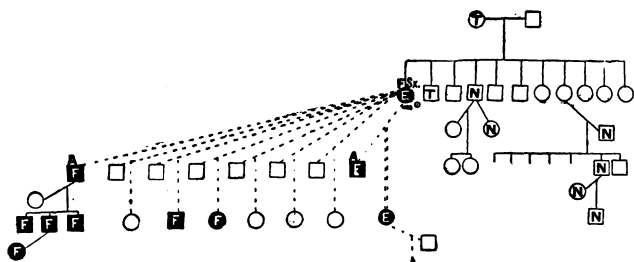


FIG. 2. This chart is a good illustration of the source of a large number of almshouse inmates. The central figure is an epileptic woman who has had seven illegitimate children all by different men; three of these died in infancy and the remainder are defective. This woman, who has spent the greater part of her life in the almshouse, was taken from there to keep house in a miserable hut for a feeble-minded man, one of whose feeble-minded sons married the feeble-minded sister of an epileptic man who is a patient at the New Jersey State Village. Her daughter, who is the patient, had one illegitimate child before she was cared for by the proper authorities. *E*, epileptic; *F*, feeble-minded; *A*, alcoholic; *N*, normal; *Sx*, sex offender; — — —, illegal union. Case 586.

family name, defect and locality. An index of the names of individuals charted facilitates the tracing of families from one pedigree to another. A register is kept by counties, showing as far as possible the locality from which the individual comes; the age; the institution or other care received, no care, etc., of every epileptic known to us in the state. A reference index of relatives living in different counties, states or foreign countries, together with the name and location of any institutions in which they have been treated, is also kept.

It will be seen at a glance that data thus obtained have proved to be much more significant and trustworthy than the familiar family

history obtained from the patient or his guardian at the time of his admission to the institution, and we are convinced, justifies careful study, which is more than can be said of the former history.

This study is based on 397 separate pedigrees of this number, however, seven came from the same fraternity; in another three are from the same fraternity and their mother is also a patient in the institution. In four other cases, two patients are from the same fraternity, and besides these, four others have been found to be

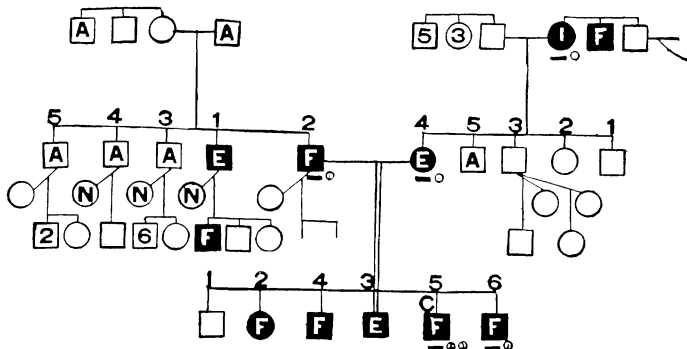


FIG. 3. The central mating in this case is that of a feeble-minded man and an epileptic woman. The man had an epileptic brother, who in turn had a feeble-minded son, while the woman came from an insane mother and had a feeble-minded uncle. There were six children; the first died in infancy, the second and fourth were feeble-minded, the third was epileptic, the fifth is a feeble-minded boy, who is at The State Home for Boys, while the last is also feeble-minded, and he is cared for at a Children's Industrial Home. The mother and father are dependent on the town for support, the mother's mother died in the State Hospital for the Insane. This mating is of the type nulliplex \times nulliplex. *E*, epileptic; *F*, feeble-minded; *I*, insane; *A*, alcoholic; *N*, normal. Case 4,369.

related, thus connecting their pedigree with others already acquired, so that only 381 different families are involved in our study.

The frequency with which the same name occurs on many of the charts indicates that there is little doubt but that future study will determine their relationship and show some of these to be of the same blood.

The total number of epileptics recorded on the charts was 756, which was 3 per cent. of the total chart population of 21,558, or 9 per cent. of the 8,698 classified individuals.

In analyzing our data, we have classed it under the six kinds of matings, as follows:

NULLIPLEX \times NULLIPLEX.

There are twenty-seven fraternities in which both parents are either epileptic or feeble-minded; 16 of these matings are principal matings and 11 secondary matings.

In three of the matings both of the parents were epileptic. Of the 28 conceptions, two were stillbirths, 3 miscarriages, 3 died before

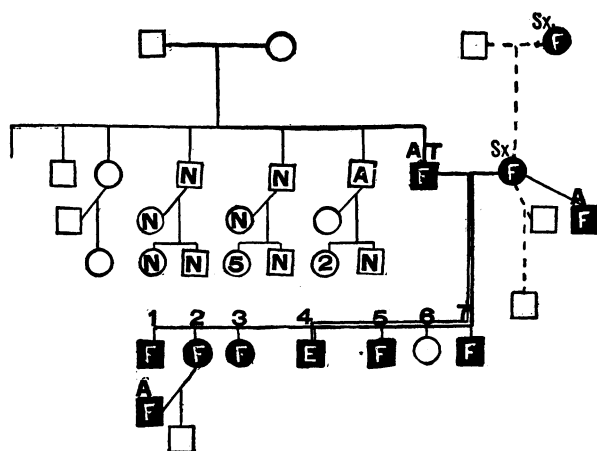


FIG. 4. This chart shows the offspring in a case where both the father and mother were feeble-minded; the father was alcoholic and died of tuberculosis, while the mother was sexually immoral and was the illegitimate child of a feeble-minded woman. There were seven children; one, the sixth, is thought to be by a different father; of the others five are feeble-minded and one is epileptic. After the father's death the mother married a feeble-minded man, who is the younger brother of her daughter's feeble-minded husband. *E*, epileptic; *F*, feeble-minded; *A*, alcoholic; *T*, tubercular; *Sx*, sexually immoral; *N*, normal; — — — —, illegal union. Case 3,037.

two years of age, and one (an infant) is too young for classification, leaving 19 about whom something definite is known. Of these, 8 were epileptic, 3 feeble-minded, and 8, who came from parents who developed epilepsy late in life, were tainted. (Fig. 1.)

In fifteen fraternities in which one parent is epileptic and the other feeble-minded, there were 81 conceptions; 7 were too young

to be classified, and 19 died before 14 years of age. Of the 55 classified, 29 were epileptic, 26 feeble-minded and 1 insane. (Figs. 2 and 3.)

In nine fraternities in which both parents were feeble-minded, there were 56 conceptions. Of these, 4 died before two years of age, 14 were too young for classification. Of the other 38 of whom something definite is known, 7 were epileptic, 28 feeble-minded and 2 drunkards, who may or may not have been feeble-minded. (Fig. 4.)

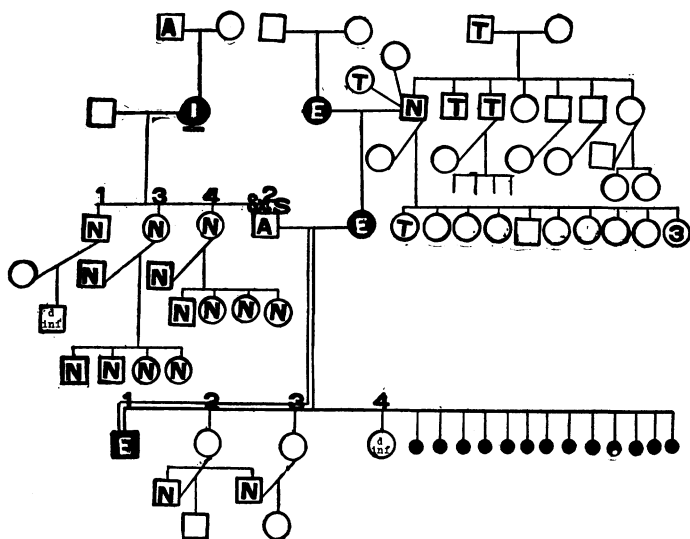


FIG. 5. In this history the mother is epileptic and descended from an epileptic mother; the father, who is alcoholic, is also syphilitic; his mother was insane. The first child is epileptic, the next two are neurotic, the last died before two years of age, and following this there were thirteen miscarriages. In contrast to the central mating this chart shows two normal matings; in these cases all of the children are normal. *E*, epileptic; *F*, feeble-minded; *S*, syphilitic; *I*, insane; *Sx*, sex offender; *N*, normal; *A*, alcoholic; *d inf*, died in infancy. Case 1,772.

These matings are of the type nulliplex \times nulliplex, and seem to justify the expectation that all children from these unions will lack the determiner for normality.

In five fraternities where one parent is insane and the other epileptic or feeble-minded, there were 29 conceptions; 5 died before 14 years of age, 2 unknown. Of the 22 available for study, 2 are

epileptics, 4 feeble-minded, 1 insane, 8 tainted and 7 seemingly normal. These latter came from two fraternities, where in one case the father's insanity seemed to be traumatic and in the other alcoholic.

NULLIPLEX \times SIMPLEX

Under this classification we have grouped separately those fraternities in which one parent was alcoholic.

In the consideration of the fraternities where one of the parents is epileptic or feeble-minded, and the other alcoholic, we have classed as alcoholic all of those parents who are habitually hard drinkers, or who go on frequent sprees.

In thirty-five fraternities there were 226 conceptions; 21 are yet too young to be classified, 79 died before 14 years of age (which is

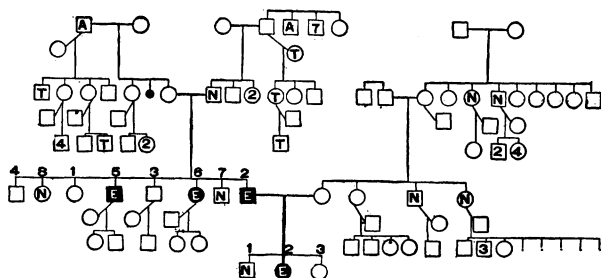


FIG. 6. In this case the father is epileptic and the mother is neurotic. The father had an epileptic brother and an epileptic sister. There were three children; the first was normal, the second epileptic and the third too young as yet for classification. This is an illustration of the nulliplex \times simplex type of mating. E, epileptic; F, feeble-minded; N, normal; T, tubercular; A, alcoholic. Case, 3,402.

35 per cent., a high death rate). Of the 126 remaining, 39 are epileptic, 38 feeble-minded, and 28 showing some other taint (1 insane, 3 migrainous, 16 neurotic, 5 alcoholic and 3 sexually immoral), with only 21 apparently normal.

In these matings of the type nulliplex \times simplex, we should expect 50 per cent. nulliplex, that is, epileptic or feeble-minded and 50 per cent. simplex, that is, apparently normal or showing only some slight defect. We have, however, 61 per cent. nulliplex, 39 per cent. simplex, the increase over the expectation being probably

due to the fact that the alcoholic parent was also mentally defective, or that the alcoholism may, through poisoning the germ cells, be a contributing cause of epilepsy. (Fig. 5.)

In addition to the above, there were six matings where one parent was insane and the other alcoholic. Of the 29 conceptions, 9 died in infancy, 6 are unclassified, leaving 14 of whom something definite is known. Of these, 7 were epileptic, 3 feeble-minded, 2 neurotic and 2 apparently normal.

In considering the fraternities in which one of the parents is either epileptic or feeble-minded, and the other "tainted," we have classified as "tainted," the migrainous, neurotic and those who are mentally weak.

There were twenty-five fraternities with 161 conceptions; 60 died before 14 years of age, 24 are too young for classification, leaving 77 for study. Of these, 27 or 35 per cent. are epileptic, 9, or 11 per cent., feeble-minded, 24 showing some slight nervous or mental weakness, and 17 normal.

In these matings we should expect 50 per cent. nulliplex and 50 per cent. simplex. We obtained 47 per cent. mentally defective and 53 per cent. apparently normal, or showing some slight weakness, which is a very close fitting to the expectation. The discrepancy may be accounted for by the possible classification as simplex of individuals who are in reality nulliplex. (Fig. 6.)

In six matings of an insane parent with a "tainted" one, there were 45 conceptions; 10 died in infancy, 9 are unclassified. Of the 26 others, 9 were epileptic, none feeble-minded, 8 tainted, with 9 apparently normal.

NULLIPLEX \times DUPLEX.

Under this classification we have tried to place the fraternities of which one parent was epileptic or feeble-minded, and the other reported normal.

In thirty-eight fraternities with 223 conceptions; 62 died in infancy, 36 are too young for classification. Of the 125 others, 39 or 32 per cent. are epileptics, 14 or 11 per cent. are feeble-minded,

and 26 or 21 per cent. are neurotic, while 46 or 39 per cent. were apparently normal.

This fitting confirms very closely with what might be expected from the type simplex by nulliplex, indicating that the parents who have been classified as duplex (normal) are really simplex, in that half their germ-cells have and half lack the determiner for normality.

Twenty of the normal parents had ancestors who showed some mental or nervous weakness, this would justify their classification as simplex. In 26 cases little is known about the ancestors of the normal parent. The available information about three would

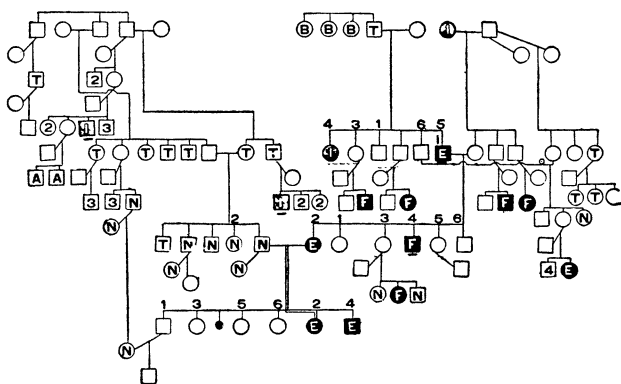


FIG. 7. The central mating in this pedigree is that of an epileptic woman, who descended from an epileptic father and has several defective relatives, and a normal man, who comes from normal ancestors. There were six children, two epileptic, and four neurotic. E, epileptic; F, feeble-minded; I, insane; T, tubercular; B, blind; N, normal. Case 2,207.

indicate that they are mentally normal. Judging from their offspring, we believe that subsequent data will show that these apparently mentally normal parents descended from tainted ancestors. (Fig. 7.)

Eleven matings of an insane and normal parent, resulted in 50 conceptions; 10 died before 14 years of age, 7 are too young for classification. Of the 33 remaining, 12 or 36 per cent. were epileptic, 2 or 6 per cent. feeble-minded, 18 or 55 per cent. seemingly normal, while 1 or 3 per cent. was neurotic.

SIMPLEX \times SIMPLEX.

Under this type of matings we have grouped those fraternities coming from matings where neither parent can be classified as normal, or called mentally deficient, but showing some mental or nervous weakness.

There were eighty-four matings of this type, with a total of 540 conceptions. 152 died in infancy, with 52 unclassified. Of the 336 others, 97 were epileptic and 17 feeble-minded, in other words, 114, or 35 per cent., were nulliplex, an excess of 10 per cent. over the expected 25 per cent. (Fig. 8.)

In these matings there was an excess of epileptic and feeble-

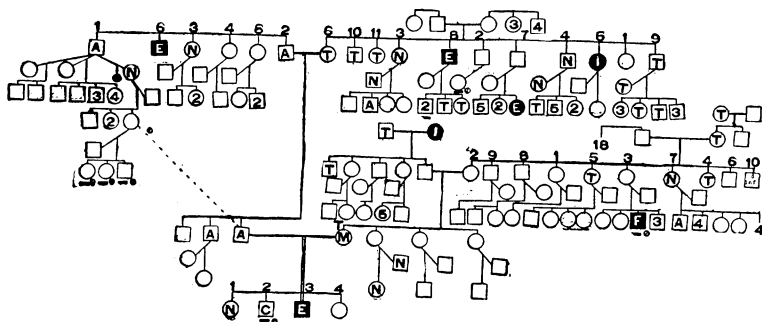


FIG. 8. In the central mating, the alcoholic, unchaste man who comes from a "tainted" strain, married a migrainous woman. There were four children: the first is normal, the second, criminalistic and has been an inmate in the State Reform School, the third is an epileptic, and the last is neurotic. This is an illustration of the simplex \times simplex type of mating. *E*, epileptic; *F*, feeble-minded; *I*, insane; *A*, alcoholic; *T*, tubercular; *M*, migrainous; *N*, normal. Case 2,029.

minded beyond the expectations, which would seem to indicate that some of these tainted conditions are more closely allied with the cause of epilepsy and feeble-mindedness than has so far been recognized. The fact that there were more than five times as many epileptics as feeble-minded persons, tends to show that the neurotic and otherwise tainted conditions are more closely allied with epilepsy than with feeble-mindedness. It is a significant fact that out of the 84 matings, in four of them both parents were migrainous, while in 23 one parent was migrainous, and 14 of these were mated

are of the type simplex \times simplex, and the findings would seem to indicate that all the matings are of this type.

DUPLEX \times DUPLEX.

Under this type of mating we have grouped all those fraternities in which both parents are recorded as normal.

In the study of seventy-six fraternities there were 441 conceptions; 62 are too young for classification or entirely unknown, 103

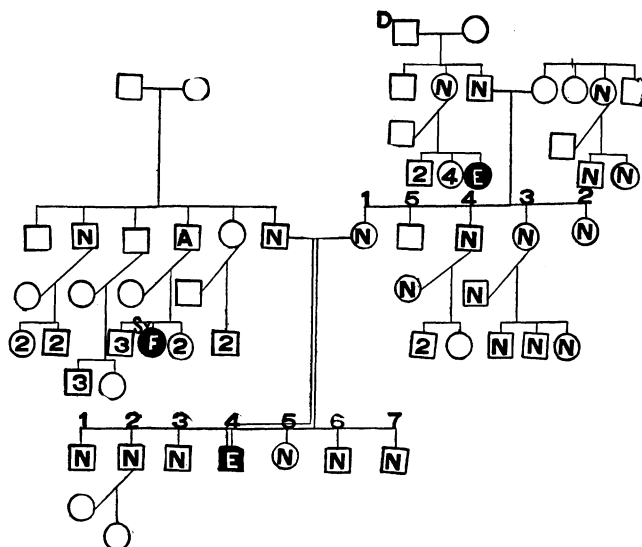


FIG. 10. This chart shows the mating of two normals. They each have defective relatives. Of the seven children the fourth is an epileptic and the others seem to be normal. *E*, epileptic; *F*, feeble-minded; *A*, alcoholic; *N*, normal. Case 2,983.

died before the age of 14 years. Of the 276 others, 172 are normal, 75, or 27 per cent., are epileptic and 3, or 1 per cent., feeble-minded, with 1 insane and 25 tainted, that is, 197 (172 + 25), or 71 per cent., are duplex or simplex in character. (Fig. 10.)

The results show that these normal parents are not duplex, but simplex, and a study of their ancestors justifies this conclusion, for in at least 45 of the matings, one or both of the parents descended from tainted ancestors.

All the available facts point toward the conclusion that the various common types of epileptics seen in institutions lack some element necessary for complete mental development, which is also true of the feeble-minded.

Two epileptic parents produce only defective offspring, when both parents are either epileptic or feeble-minded, their offspring are also defective, the defect taking the form of epilepsy, feeble-mindedness or some other neuropathic condition. This is also true of feeble-minded parents.

In the light of our present knowledge, the results obtained from the study of our data do not justify the classification of the reported normal parents of epileptics as duplex. We are forced to the belief that their germ plasm is simplex, and feel confident that more complete data would show the taint in their ancestors.

Our data seem to support the belief that alcohol is a cause of defect, in that more children of alcoholic parents are defective than where alcoholism is not a factor.

That there are more than five times as many epileptics as feeble-minded persons in those fraternities coming from matings where neither parent can be classed as normal, or called mentally defective, seems to indicate that neurotic and otherwise tainted conditions are more closely related to epilepsy than to feeble-mindedness.

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